

# Feedback Sensors for Closed Loop Additive In-Space Manufacturing, Phase I

Completed Technology Project (2018 - 2019)



## Project Introduction

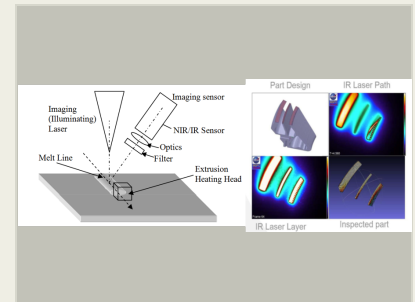
This solicitation calls for online quality control to be applied to In-Space Manufactured (ISM) additive manufactured parts. Our proposed approach is integrated precision scanning of the additive manufactured (AM) parts and feedback of that data back into AM layer by layer process control. The goal is to augment Space Manufacturing AM process controls with verifiable feedback enabling improved process stability and part quality to significantly reduce the risk associated with complex AM parts, especially those with critical hidden internal geometries or other features not readily measured with non-destructive tests/measurements.

The proposed approach proposes to leverage and productize technology disclosed by the Marshall Space Flight Center in reference number MFS-TOPS-70 case number MFS-33013-2, a method that determines geometric differences (flaws) between the designed model and the printed part/component by employing IR cameras to collect accurate temperature data that can be validated against valid thermal models. We will add to that approach by also employing mature but improved NIR optical measurement to implement an additional function on the moving AM extrusion head. We then will employ the 3D data acquired by this embedded scanning sensor to (a) provide dimensional verification of part geometry after each deposition pass, and (b) when employed real time to modify machine control – likely requiring modification of the AM machine's X, Y, Z, and feed rate controlling mechanisms that have to be different depending on ambient conditions (temp, humidity, and gravity) and deposited materials (plastic and plastic emulsion material differences).

## Anticipated Benefits

The goal is to develop a real-time system active feedback control and process characterization applied to multiple materials, specifically in Phase I to FDM parts, and in Phase II to support in-space manufacturing employing the ISS AMF. This will show how closed-loop AM manufacturing is feasible and changes the quality and consistency of AM manufactured parts for aerospace parts fabrication in support of rapid development and in-situ manufacturing for long-distance space missions.

Key potential customers will be the military for out-of-production spares, industry for low quantity high quality parts manufacturing, and more specialized makers of other products like prostheses or 3D art. We will also partner with interested AM machine OEMs.



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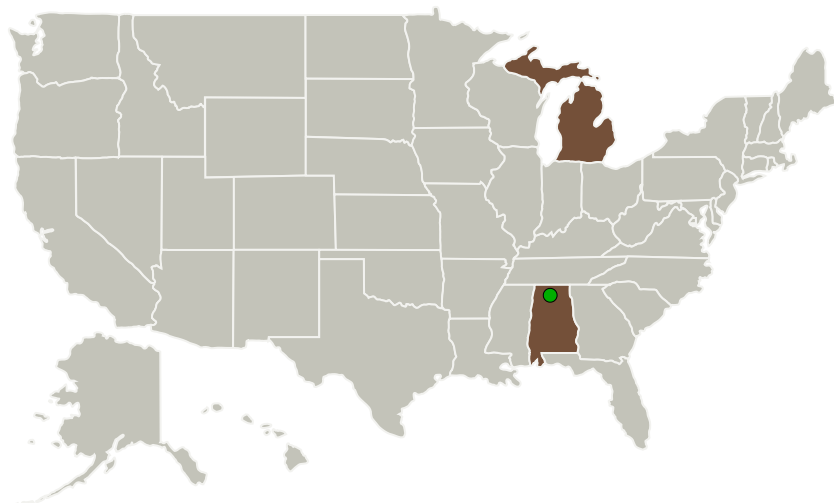
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
● Marshall Space Flight Center (MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations	
Alabama	Michigan

## Project Transitions

▶ **July 2018:** Project Start

✓ **February 2019:** Closed out

**Closeout Documentation:**

- Final Summary Chart(<https://techport.nasa.gov/file/141337>)

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

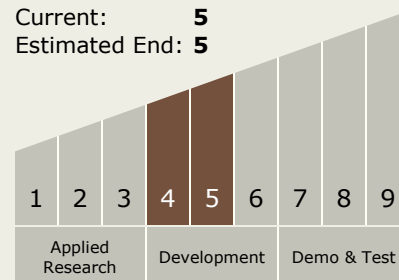
Carlos Torrez

**Principal Investigator:**

Charles Jacobus

## Technology Maturity (TRL)

Start: 4  
Current: 5  
Estimated End: 5

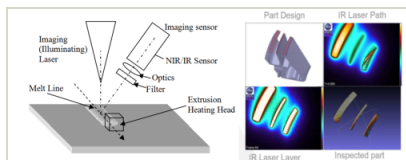


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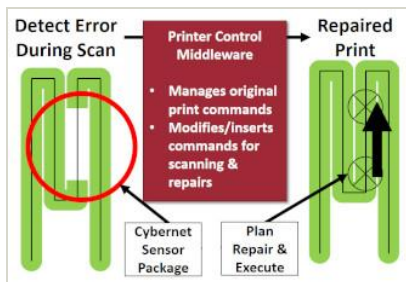
## Images



### Briefing Chart Image

Feedback Sensors for Closed Loop Additive In-Space Manufacturing, Phase I

(<https://techport.nasa.gov/image/129429>)



### Final Summary Chart Image

Feedback Sensors for Closed Loop Additive In-Space Manufacturing, Phase I

(<https://techport.nasa.gov/image/132448>)

## Technology Areas

### Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - └ TX12.4 Manufacturing
    - └ TX12.4.1 Manufacturing Processes

## Target Destination

Earth